CLAIMS

WE CLAIM:

1. An ultrasonic elastography system comprising:

an ultrasonic transducer system adaptable to provide a set of echo signals from at least two different angles and from a plurality of voxels in a region of interest, the set of echo signals including first echo signals taken with tissue of the region of interest in a first compressive state and second echo signals taken with tissue of the region of interest in a second compressive state; and

a processor combining at least portions of echo signals from different angles to produce at least one compounded strain measurement for a voxel in the region of interest.

2. The ultrasound elastography system of claim 1 wherein the processor provides a strain extractor and a combiner operating together to receive the set of echo signals and produce the compounded strain measurement.

3. The ultrasound elastography system of claim 2 wherein the strain extractor first extracts at least one strain measurement from portions of at least two pairs of ultrasonic echo signals at different angles and provides the strain measurements to the combiner to combine the strain measurements to produce the compounded strain measurement for the voxel.

4. The ultrasound elastography system of claim 2 wherein the combiner first combines portions of at least two pairs of ultrasonic echo signals from different angles to produce at least two pairs of combined echo signals and then provides the combined echo signals to the extractor which extracts the compounded strain measurement for the voxel.

5. The ultrasound elastography system of claim 2 wherein the processor receives an angle of the ultrasonic echo signals underlying the strain measurement to convert the strain measurement to an equivalent strain measurement along a predetermined strain axis; and combines the converted strain measurements to produce the compounded strain measurement.

6. The ultrasound elastography system of claim 5 wherein the predetermined strain axis is an axis of compression of the region of interest.

7. The ultrasound elastography system of claim 5 wherein the predetermined strain axis is perpendicular to an axis of compression of the region of interest.

8. The ultrasound elastography system of claim 5 wherein the conversion of strain measurements to equivalent strain measurement multiplies the strain measurements by a weighting function based on a difference between an angle of the strain measurement and the predetermined strain axis.

9. The ultrasound elastography system of claim 8 wherein the predetermined strain axis is an axis of compression of the region of interest and wherein the weighting function is $w(\theta) = 1/(\cos^2 \theta - \nu\sin^2\theta)$;

where ν is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

10. The ultrasound elastography system of claim 8 wherein the predetermined strain axis is an axis perpendicular to an axis of compression of the region of interest and wherein the weighting function is $w(\theta) = 1/(\sin^2 \theta - \nu\cos^2\theta)$;

where ν is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

11. The ultrasound elastography system of claim 2 wherein the angle of compression changes with changes in the angle of the echo signal and wherein the predetermined strain axis is an axis angled with respect to the compression of the region of interest.

12. The ultrasound elastography system of claim 11 wherein the weighting function is $w(\theta) = 1/(\cos^2 \theta - \nu\sin^2\theta)$;

where ν is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

13. The ultrasound elastography system of claim 1 wherein one compressive state is no compression.

14. The ultrasound elastography system of claim 1 wherein the processor combines the set of echo signals at the different angles to produce at least two compounded strain measurements of the voxel along at least two strain axes.

15. The ultrasound elastography system of claim 14 wherein the two strain axes are perpendicular.

16. The ultrasound elastography system of claim 14 wherein one of the two strain axes are perpendicular to the compression.

17. The ultrasound elastography system of claim 1 wherein the processor provides compounded strain measurements for multiple voxels to provide a strain image output.

18. The ultrasound elastography system of claim 1 wherein the processor provides an output of the group consisting of: Poison's ratio of the tissue of the region of interest, and shear strain of the tissue of the region of interest.

19. The ultrasound elastography system of claim 1 wherein the processor receives a series of position signals from the ultrasonic transducer system and including a combiner using the position signals to match corresponding portions of the echo signals by voxel to produce the compounded strain measurement.

20. The ultrasound elastography system of claim 1 wherein the processor includes a correlator correlating values of the echo signals over each voxel to determine a maximum correlation and using the maximum correlation to match corresponding portions of the echo signals produce the compounded strain measurement.

21. A method of ultrasonic elastography system comprising the steps of:

(a) collecting with an ultrasonic transducer, first echo signals from at least two angles and from a plurality of voxels in a region of interest in a first compressive state;

(b) collecting with the ultrasonic transducer second echo signals from the angles and from the plurality of voxels in a region of interest in a second compressive state; and

(c) combining at least portions of first and second echo signals from different angles to produce at least one compounded strain measurement for a voxel in the region of interest.

22. The method of claim 21 wherein step (c) includes an extraction step extracting strain measurement and a combining step combining information from echo signals of different angles to produce the compounded strain measurement.

23. The method of claim 22 wherein the extraction step first extracts at least one strain measurement from portions of at least two pairs of ultrasonic echo signals at different angles and the combining step combines the strain measurements to produce the compounded strain measurement for the voxel.

24. The method of claim 21 wherein the combining step first combines portions of at least two pairs of ultrasonic echo signals from different angles to produce at least two pairs of combined echo signals and the extracting step extracts strain from the combined echo signals to produce the compounded strain measurement for the voxel.

25. The method of claim 21 wherein the processor receives an angle of the ultrasonic echo signals underlying the strain measurement to convert the strain measurement to an equivalent strain measurement along a predetermined strain axis; and

combines the converted strain measurements to produce the compounded strain measurement.

26. The method of claim 25 wherein the predetermined strain axis is an axis of compression of the region of interest.

27. The method of claim 25 wherein the predetermined strain axis is perpendicular to an axis of compression of the region of interest.

28. The method of claim 25 wherein the conversion of strain measurements to equivalent strain measurement multiplies the strain measurements by a weighting function based on a difference between an angle of the strain measurement and the predetermined strain axis.

29. The method of claim 28 wherein the predetermined strain axis is an axis of compression of the region of interest and wherein the weighting function is $w(\theta) = 1/(\cos^2 \theta - \nu\sin^2\theta)$;

where ν is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

30. The method of claim 28 wherein the predetermined strain axis is an axis perpendicular to an axis of compression of the region of interest and wherein the weighting function is $w(\theta) = 1/(\sin^2 \theta - \nu\cos^2\theta)$;

where ν is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

31. The method of claim 22 wherein the angle of compression changes with changes in the angle of the echo signal and wherein the predetermined strain axis is an axis angled with respect to the compression of the region of interest.

32. The method of claim 21 wherein the weighting function is $w(\theta) = (\cos^2 \theta - \nu\sin^2\theta)$;

where νP is an estimate of Poisson's ratio of the tissue of the region of interest; and

θ is the angle between the angle of the strain measurement and the predetermined strain axis.

33. The method of claim 21 wherein one compressive state is no compression.

34. The method of claim 21 wherein the processor combines the set of echo signals at the different angles to produce at least two compounded strain measurements of the voxel along at least two strain axes.

35. The method of claim 24 wherein the two strain axes are perpendicular.

36. The method of claim 24 wherein one of the two strain axes are perpendicular to the compression.

37. The method of claim 21 wherein step (c) produces compounded strain measurements for multiple voxels to provide a strain image output.

38. The method of claim 21 wherein step (c) provides an output of the group consisting of: Poisson's ratio of the tissue of the region of interest, and shear strain of the tissue of the region of interest.

39. The method of claim 21 including the step of receiving a series of position signals from the ultrasonic transducer and matching corresponding portions of the echo signals by voxel to produce the compounded strain measurement.

40. The method of claim 21 including the step of correlating values of the echo signals over each voxel to determine a maximum correlation, and using the maximum correlation to match corresponding portions of the echo signals, produce the compounded strain measurement.

41. The method of claim 21 wherein the echo signals are collected at angles differing by no more than 5 degrees.

42. The method of claim 21 wherein the echo signals are collected at angles differing by less than 1 degree.

43. The method of claim 21 wherein the echo signals are collected at angles ranging over 180 degrees.

44. The method of claim 21 wherein the echo signals are collected at angles ranging less than 90 degrees.

45. The method of claim 21 wherein the echo signals are collected of voxels aligned within a single image plane.

46. The method of claim 21 wherein the echo signals are collected of voxels distributed over a volume extending for multiple voxels in two dimensions perpendicular to a direction of ultrasonic propagation.